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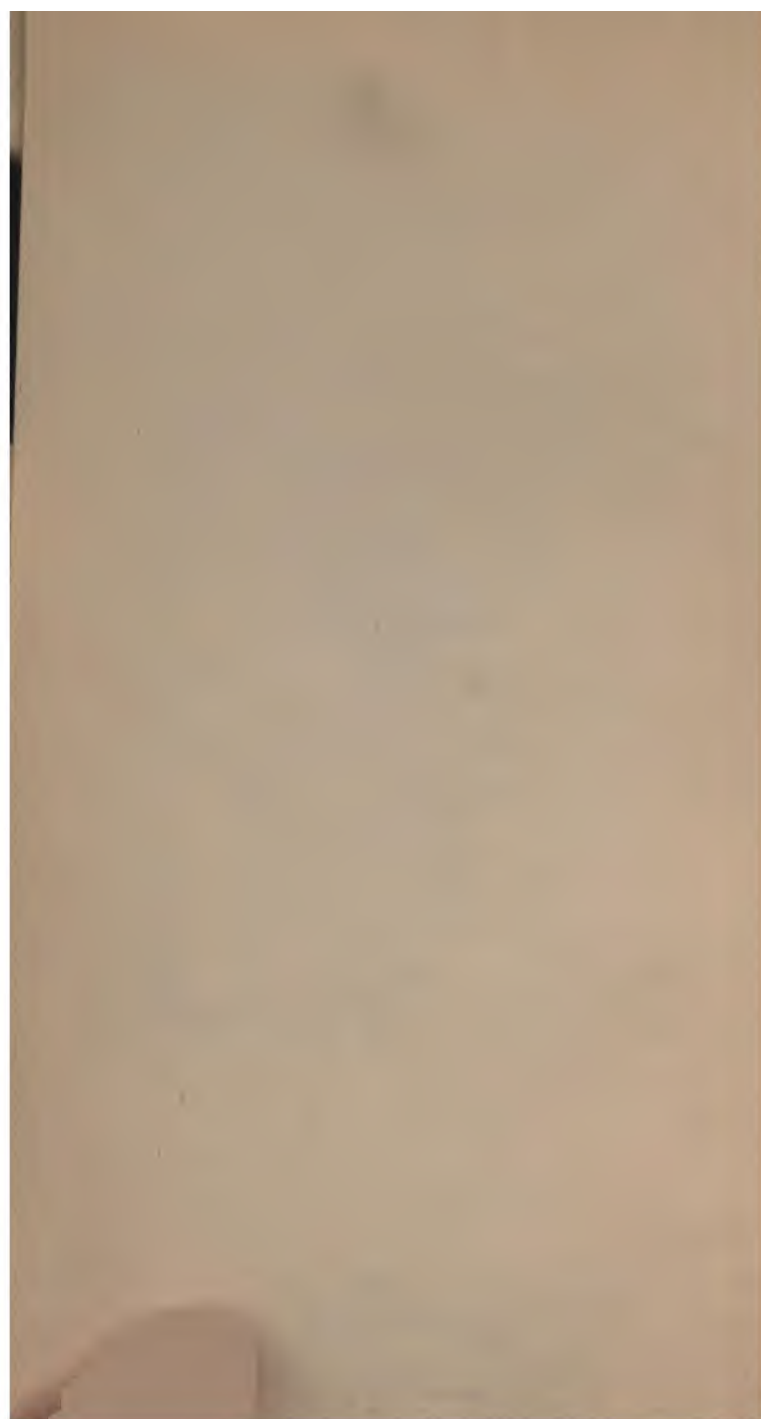


**BEQUEATHED BY  
CAROLINE EUSTIS PEABODY  
OF CAMBRIDGE**

THE  
JOURNAL OF THE  
ROYAL ANTHROPOLOGICAL INSTITUTE  
OF GREAT BRITAIN AND IRELAND

Vol. 40, Pt. 1  
1910  
LONDON  
1910

Printed by the Royal Society



*Barro Stiles*

*Dec 15. 1762*

*(Signature)*



AN

ESSAY

ON THE

INVENTION,

OF MAKING

SAND IRON.



The Rev. Dr. East died April 22 1763. Oct. 78.  
Nine days before his death he received this Letter from  
Dr. Templeman about the Society of Arts, &c. London.

"Sir I have the pleasure to send you the congratu-  
lations of this Society on the important discovery  
you have made of the great quantity of iron to be ob-  
tained from the black sand of America.

"Your letter concerning it came me with universal sa-  
tisfaction, and the gold Medal of the Society was unani-  
mously voted you.

"I am ordered to return you their thanks for  
communicating so important a discovery & also for the  
printed Essay you are so obliging as to send them.

"I must beg the favour of knowing to whom you  
should commit the gold Medal designed for you.

"The Society are very sensible of your publick service  
in promoting their views for the Advancement of the British  
Colonies; and your Reading is promoting them but  
things as they requested of you. With the sincerest  
Wishes of long life & health to one who so nobly  
dedicates his Thoughts and Time to the public  
good, I have the honor to subscribe myself, in  
the name of the Society, Sir,

Your most obliged

Humble servant

Grand Janry 6. 1763.

Peter Templeman

Secretary.

"To the Rev. James Eliot"

The Medal was received Oct. 3. 1763 by Colonel  
Aaron Hill at that time of late Dr. Eliot. It weighs  
one Ounce 8. 10 Grs. - is near one fourth of an Inch  
thick - & one Inch & three Quarters Diameter - is  
the Society's Eighteenth Medal & dated 1762.

A N  
E S S A Y  
O N T H E  
I N V E N T I O N,  
O R  
A R T of making very good,  
if not the best I R O N, from  
black Sea Sand.

---

By Jared Elliot, M. A.  
Of KILLINGWORTH.

---

*They shall seek of the Abundance of the Seas, and of the  
Treasures hid in the Sand. DUT. xxiii. 19.*

*Iron is taken out of the Earth, and Brass is molten out  
of the Stone. JON xxviii. 2.*

*Iron sharpeneth Iron, so a Man sharpeneth the Courage  
of his Friend. PROV. xxvii. 17.*

---

N E W - Y O R K :

Printed and Sold by JOHN HOLT, at the New-Printing-  
Office, near Burling's Slip, 1762.

Chem 7237.52



**THIS ESSAY,**

**Is HUMBLY DEDICATED**

**TO the Honourable and  
Laudable SOCIETY, instituted  
at LONDON, for the Encou-  
ragement of Arts, Manufactures,  
and Commerce ;**

*By their most humble,*

*most obedient*

*Attendant in  
Annals 1762.*

*Servant,*

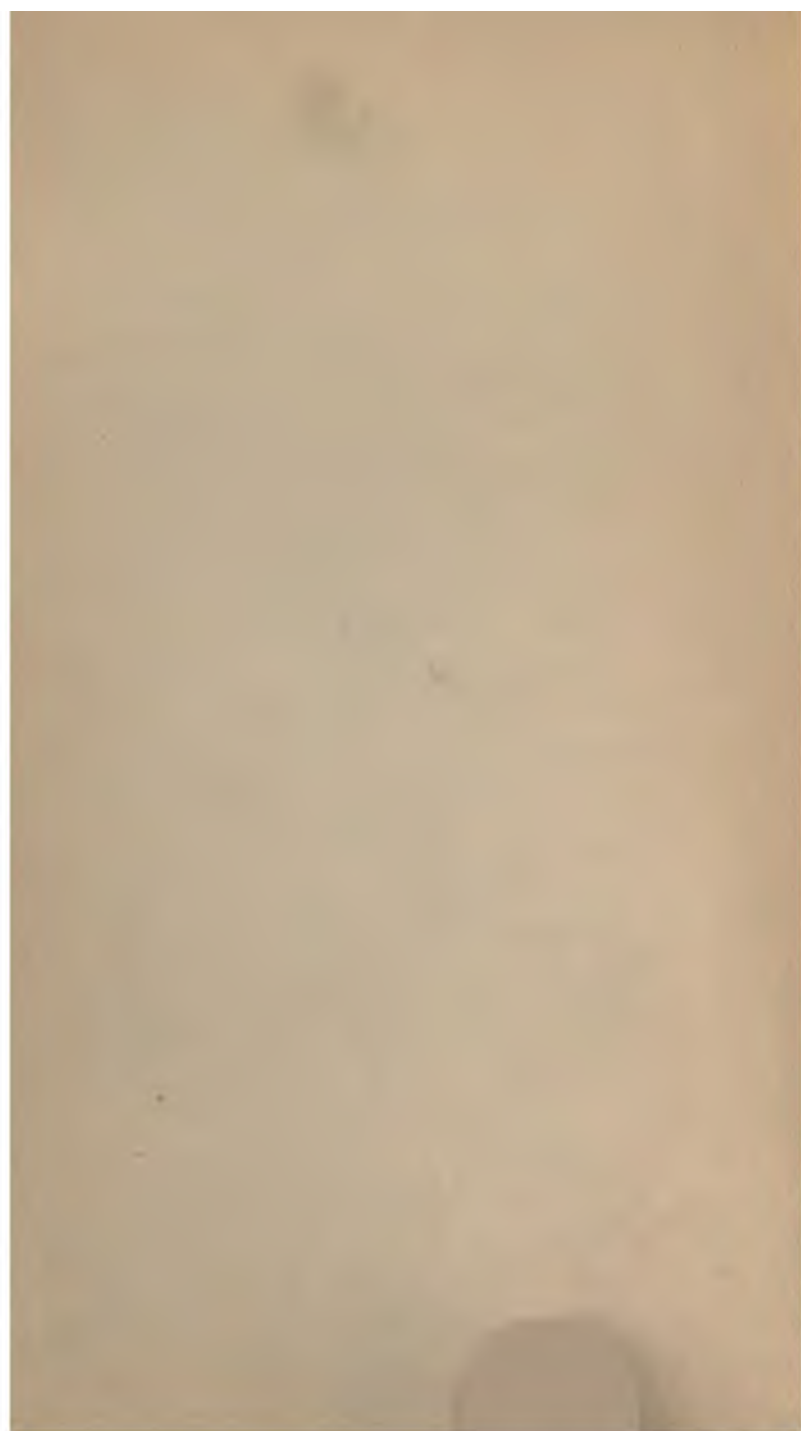
**JARED ELIOT.**

*An ESSAY, on the Invention or Art of  
making Iron from Sea Sand, &c.*

**S** one great End of our Existence,  
consists in being useful to each other  
**A** in social Life, in a careful Discharge  
of all relative Duties incumbent on  
us; sensible of this, according to  
my small Capacity I have endeavoured to pro-  
mote the Good, and general Interest of the  
Community of which I am a Part, and with  
whom I have a strong Connection; but by  
Reason of my Situation in the Country, Want  
of proper Instruments to lend Assistance in  
searching into the Secrets of Nature, and State  
of Bodies, have been able to make but a slow  
Progress in that which I have so much at Heart.

With this View, I now give an imperfect  
History of a singular Sort of Sand, called scour-  
ring Sand; denominated so, on the Account  
of its peculiar Finess to scour, burnish, and set  
a Gloss upon Pewter, and other Metals: It is  
also more extensively known by the Name of  
Writer's Sand, much used by Merchants and  
Printers.

Of this Sand there are three Sorts, black,  
brown, and red; the black is much the best  
for every Use as yet known: These Sands at  
certain Seasons cover the Face or Surface of  
the Sea Beach, to the Extent of ten, twenty,



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and even to sixty Rods in Length, in some Places: Had they not been distinguished on the Account of the aforesaid Uses, their uncommon Colour, and ponderous Nature; they might have remained unnoticed to the End of Time. These Sands appear and disappear at different Seasons of the Year, they appear in the Summer and Autumn, and in a great Measure disappear in the Winter. They lie in the greatest Degree of Depth close in with the Upland, then fall away gradually towards the Sea,--know not whether there be any beyond Low-Water Mark.

I once thought these Sands were brought up by the Waves of the Sea, and then by the Agitation of the Sea in Storms, and by the great Hurry of Waters, were carried back again to the Sea; but am now fully convinced that this Conjecture was unphilosophical, and not founded on true Principles: As the Solution of that Phenomenon did not then appear any Way interesting, my Thoughts were unattentive, nor was I concerned whether my Conjecture was right or wrong; but I am now certain, that the black Particles of these Sands are Iron, well washed from all Impurity, and that they are derived from the upland Earth adjacent, as also from other distant Lands; I conclude so, for the following Reasons;

*First*, Because these Sands are not found on Flats or a low Beach, but are found at the Foot of proper upland Earth.

32. They are found only where the Sea hath made Encroachments upon the Land.

33. Because that when Fragments of the Earth, are broken off, or you dig into the Ground, you will find the same Sort of Iron Particles as you find on the Beach below; these Particles of Iron in the Ground, are of the same Colour and Dimensions with those on the Beach; at least they appear to the naked Eye, with which I am obliged to rest satisfied, having no Microscope to ascertain and determine the Thing: I suppose that these Particles are Iron in their primitive and original State; and that these Particles were created at the Beginning with other Parts of the Earth, viz. Gravel, Clay, Chalk, and Grit Sand:

That what has been called the Generation of Metals in Mines, and those great Beds of Ore called Mountain or Rock Iron, as also Bog Mine Ore, both are no other than a Collection of these Iron Particles, conveyed by Water to such Places as are fit, in their Formation, as in a Bed to receive them; where we find them in such great Masses, and in such a State of Cohesion, that we are obliged to break it up with Crow Bars, Sledges, Wedges, and Gun Powder. There is good Reason to conclude, that this great Collection of Sand Ore would long before now have been formed into Masses as we find it in Bog Mines, and in Mines of Rock Iron, were it not that these Iron Particles are so frequently put in Motion by the Agitation

of the Sea, in its Flux and Reflux, that there is not Time to form a Cohesion; this Motion of the Iron Particles is what keeps them so pure and free from all fabulous and other heterogeneous Mixtures; which I suppose to be the Reason why such a small Quantity of this Sand Ore will afford such a large Quantity of Iron, beyond that of Bog Ore, or Mountain Ore: The Iron Mines of *New-Milford* and *Salisbury*, which are accounted very good (if I remember right) afford but one Ton of Iron from three or four Tons of the Ore; ordinarily they reckon four Tons, one with another, to a Ton of Iron.

I formerly had an Interest in the Ore Bed in *Salisbury*, which I have sold; the other in *New-Milford* I still retain, but having committed it to the Care of one of my Sons settled in those Parts; I have in some Measure forgot the Proportions of Ore to Iron, but think I am not mistaken; and can correct afterwards if I find any Mistake.

When we dig thro' these Ore Sands, underneath we find a yellow Substance, much resembling what those who dig up the Bog Ore call the Mother of Iron, which they suppose to be the Pubulum and Food of the growing Bed of Iron; what it is I know not; possibly it may be the Cement which holds the Particles of Iron together, but is prevented in doing its Office by the frequent Motion of the Particles of Iron, and so falls to the Bottom where we find it.

These

These Iron Particles are scattered in many Parts of the Earth, and carried forward by the Water from Hills to Brooks, from Brooks to Rivers, till they fall into the Sea, mingle with the Sand Ore, and add to the Quantity, or to some proper Bed. Travelling the Road with the Reverend Messrs. *Ruggles* and *Todd*, at the Bottom of an Hill which we had descended, while we were discoursing on this very Subject, we observed some Sand brought down by the Water, nigh a Brook, which it might probably reach the next Rain; on the Top of that Sand there was a thin Stratum of a blue Colour, we had nothing convenient to take off this Stratum, but took up all together, brought it to my House, and dried it; there was three Penny Weight of Sand, from which we extracted with the artificial Magnet 15 Grains of Iron Particles, which were in Figure and Colour the same with the Sand Ore.

If it be objected, that as Iron is much heavier than Water, so it must be contrary to the Laws of Gravitation to suppose Iron to be transported in Water: If we consider how Iron may be plated so thin as to swim in Water, and that these Particles of Iron are much less than Plates made by Hand, it is not strange they should swim.

As these Particles of Iron were on the Surface of the Sand, so they must have floated on the Top of the Water by which they were conveyed; if these Particles of Iron were much larger

larger, the Velocity and rapid Motion of the Water might thrust them forward, as we see Gravel and even great Stones tumbled forward by the Force of Water. Since this Observation was made, Persons that are curious and attentive, have seen frequently in the Roads and elsewhere, these Iron Particles.

From hence we may conclude the Usefulness of Water, not only in Vegetation, but also for Transportation of Bodies to the Place of their Destination; so what a Political Writer said of the *Dutch*, that they were the grand Carriers of the World, may with greater Propriety be applied to Water. Water not only serves to bring together the Materials which form a Tree, or a Mine of Iron, but also unites them together; it is the grand Cement or Bond of Union; take away Water from Wood and it will become like Powder of Post, take away Water from common Stone and it become as Sand; extract it from Limestone (which as *Borehaave* saith, yields the most Water) it will become Lime in fine Powder; so I suppose, if Water was taken from Bog or Rock Ore, it would become like this Iron Sand Ore.

Many Years past a Number of Proprietors in an Iron Work, being in Want of Iron Ore, heard of a great Quantity in an Island; they sent and found a large Bed of it, but the Water which had fed and maintained it being drawn away, or dried away, the Mine was starved, become dry like an Honey Comb, when

Comb, when all the Cells are destitute of Honey, and therefore would yield no Iron.

I was also informed of another Iron Mine at *Windsor*, which was so richly fed with Water, fully impregnated with Iron Particles, that the Ore being taken away, the vacant Bed in a Number of Years was replenished with a new Stock fit for Use. It is consistent with Reason to suppose, that as it is with Fire, Water, Air, and Earth, so it is with Iron, which is a component Part of the Earth; that there was at first, just such a Proportion and Quantity created, which is never more nor less, and hath so continued from the Beginning, and will so the End of Time. The Fire dispersed in all Parts of the World, is gathered and collected into one or many Places, and is increased according to the Proportion of Fuel, where it is put in Motion; which is vulgarly called a Fire. It is as easy to strike Fire with Flint and Steel, or if you have Wood, to kindle a Fire in *Greenland*, as in *Persia*, or the hottest Part of the World:

Water which is raised from the Seas, Lakes, Ponds and Rivers, and carried in Clouds over the Land, is let fall in Dews and Rains, and then returns by Rills, Brooks and Rivers, to the Places prepared to receive it; and as Water continues its circular Motion and Round, so I conceive it is with Iron; by the Water the Particles of Iron are carried to a proper Bed or Receptacle, thence it is taken and wrought for the

the Use of Man, and is worn out in his Service ; or contracts a Rust and is consumed when it is worn away, as by the Earth in plowing, or from Horses Shoes in travelling, or from Iron Shod Wheels in carting, or by grinding with a grind Stone : The Iron by these Means, reduced again to fine Particles, and returns to the Earth again : When it is corrupted by Rust, this is much as when a Tree rots, or a Man dies, they Each return to Mother Earth again, these same Particles of Iron then worn away, are not annihilated or lost, but being joined with Sulphur, and those other Materials which constitute Iron Ore, it proceeds and takes the same Journey round till it comes to the Smith's Forge again : Under all these Changes and Revolutions there is no Addition ; the same Quantity as there was at first, there remains the same still, and no more.

A Piece of Iron Ore was sent to me as a Curiosity from *Salisbury*, taken from the Ore Bed in that Place ; it was in the Shape and Form of three Icicles, two or three Inches long, and joined to a Body of Ore like Fingers to the Hand ; Water impregnated with Particles of Iron, had ran down upon three Spires of Grass as Conductory to the Mineral Water, the Water from Time to Time drying away, left the Iron Particles in the above said Form :-----Which is a farther Evidence, that Iron in its primitive and original State, is in very small Particles, and are collected and brought together

ther by Water, and there formed into Masses of various Forms, as we find in what we call Iron Mines.

Iron if considered either Mechanically or Medicinally, is the most useful Metal in the World; An Ax made of Iron and Steel is for all Mechanical Uses very much to be preferred to an Ax of Gold; Steel is only Iron differently modified; if Amputation is to be performed, the Surgeon and Patient would choose a Knife of Steel, rather than a Knife of Gold. In the Rebellion under *Pizarro* in *Peru*, they were obliged for want of Iron to Shoe their Horses with Silver, but it was but poor Stuff for that Use compared with Iron.

Medicinally used it is greatly preferable to other more costly Metals. There has been much said of *Aurum Potabile*, and of Preparations of Silver, but they are but splendid Trifles compared with Preparations of Iron; but let the Preparation or Composition be what it will, whether a Water, a Powder, or a Salt, still it is Iron; these Preparations pass through the Body, and return again to their original State.

How useful is this Metal for the Forging and making the Instruments of Agriculture, for procuring our necessary Food; for making Instruments of War for our Defence and Safety; for carrying on our Trade and Commerce, so advantageous to social Life: and therefore procuring

ering a sufficient Store of it must be of great Importance to Mankind.\*

What I have further to write on this Subject, not only for the Sake of Order and greater Precision, but even from Necessity too, will be in the Manner of a Journal. For now entering on the Borders of *Terra incognita*,—can advance not one Step forward, but as Experience my only Pole Star shall direct, am obliged to write as poor Men live, from Hand to Mouth, and as Light springs up before me as I advance.

To trace the Matter therefore from the Beginning; Some Years past viewing this black Sand, the present Subject of writing, with particular Attention, was very much of the Mind that the black Particles were Iron; if it had been tried with a Magnet and was not affected by it, it would not have alter'd my Resolution to try it if an Opportunity should present, having been credibly informed that the

\* It is well known that Mercury or Quicksilver is a mere Proteus, can by Art be so ordered, as to appear in a great Variety of Forms, of divers Colours, Consistence, and Operation; as that of Salves, Ointments, Pills, and Powders; yet can be reduced back to its primitive State---Yes, of itself it inclines to return to its original State or Condition. for in the Grave Dust of those who in Life had been salivated, it has been found returned back to Quicksilver with all its true Qualities, tho' it had been exhibited in a very different Form.---So Iron after it has passed through several Stages, and subsisted under various Forms, and having assumed different Types, Colours and Figures, may return each Particle to its original and primitive State: As we may conclude both from Analogy and Experience that this is the Case---From these Facts we may infer, that the Doctrine of the Resurrection is neither inconsistent with, or contrary to the true Principles of Philosophy, as founded on Observation and Experience.

~~the Mountain Ore of New-Milford, was not~~  
 affected by the Magnet, even when it was pul-  
 verized.

Having had no Opportunity of making a Trial, the Matter rested till the last Year, when my Son erected Iron Works in this Town, in order to refine Pig Iron; upon that I resumed the Purpose of making a Trial, to see if Iron could be made from it; it is true, I might have sent of this Sand to an Iron Work at a Distance: If I had, how unavailing would it have been, where I had neither Interest or Authority to stem the Tide of Prejudices that there is against Projectors, and the seeming Impossibility of making Iron from Sea Sand? The Owner of the Works, and the Workmen would have united in rejecting such a silly Proposal: A Projector is under discouraging Circumstances, he must make his Face harder than a Rock; for if he succeeds in any important Undertaking, it is then depreciated as no great Atcheivement, and within the Reach of an ordinary Capacity; if he fails, it spreads general Joy, and he becomes a Subject of Ridicule, as a *Jeffery Gimcrack*, or a Second Don *Quixote*; and indeed if the Undertaking be either uselets, or impossible; such as the Art of Flying, the grand Catholicon, or the Philosopher's Stone, the Projectors are truly ridiculous.

Mentioning some Things of this Nature to my learned and worthy Friend *Benjamin Franklin*, L. L. D. Esq; to whom I am under great Obligations on many Accounts; he very

specifically observed, that such Treatment was neither just nor political ; that the *Germans* acted a wiser Part, for if a Project failed, unless it was ridiculous in itself, the Undertaker was named with Respect, saying though it failed, yet it was well imagined.

If some Body had not happily projected for us the Art of making Iron and Steel till this Time, we might have been confined to the Use of Stone Hoes and Axes, as were the miserable original *Indian* Inhabitants of this Land, and are even to this very Day.

Nov. 1761. My Son's Iron Works being erected as I said before ; some Time last November I rode down to the Beach, where I found the black Sand had in a great Measure disappeared. I filled my Saddle-Bags with the black Sand, which I gathered from the Surface of the red Sand, but the Chaffery was not then finished, and the Refinery not being fit for such a Purpose, the Trial could not be made, it was therefore necessarily suspended till the first Week in January. ~~1762~~

The Sand being weighed, which was designed to be used in the Trial, we desired the Workman to use his best Skill to see if he could make Iron from it : Against which, the Workman objected three Things.

1<sup>st</sup>, That he was not a Bloomer by Trade, but a Refiner, therefore it was out of his Province ; but as there was such an Affinity between these two Occupations, we did not doubt  
 1762. 1<sup>st</sup> Jan. 1762. you made me think Jan. 1762.

doubt his Skill and Ability to do it, if doped it could be.

2d. That notwithstanding the Weight and Appearance of this Sand, he much doubted whether it contained Iron Ore or not.

3d. He farther observed that if it were Iron Ore, it consisting of such very fine heavy Particles like Flesh without Bones, having nothing to sustain it, would run down among the Coals, sink to the Bottom, full too low, and consequently never gather into a Mass and form a Loop.

This, I must confess, was a formidable Objection, a Difficulty which I had foreseen, and which we knew not how to obviate, otherwise then by adding to the Sand some Cinder or Slag, which had flowed from Pig Iron in the Working ; notwithstanding this Difficulty, my Son and I were determined at all Events, that a Trial should be made. Besides the Exertion of Authority, we thought it best to engage the Workman to exert himself, and use his best Skill by motives of Honour and Interest ; let him know the Importance of the Undertaking ; he being a sober Man, who would use strong Drink with Moderation and Temperance, I promised him that if he could produce a Bar of Iron from that Sand, I would send him a Bottle of Rum. The Workman used great Diligence, Labour, Patience, and as far as I was capable of judging Skill too : As there were a Number of People waiting to

see the Issue of this singular Undertaking, who grew uneasy with long Attendance, we diverted ourselves as well as we could. I told them that it had been said of *Spaniards*, that when they were angry with a Man, the utmost that Ill-Will could suggest was, that they wished that he might be always employed in Building, and wait for a Man that should never come : That our present Situation made me think of a certain whimsical Enthusiast, who told his Wife, that if she had primitive Faith as he had, Stones might be turned into Bread ; therefore ordered her to heat the Oven well, then to put in Stones, and close the Mouth in good Order ; after two Hours baking directed her to draw the Bread ; before she opened the Oven, said, *I do not believe that it is Bread ;* on Sight of the Stones said, *I told you so, that it would not be Bread ;* to which the Man replied, *All this is because you did not Believe ;* but said she, *why is it not half Bread ?* The Workman being under great Discouragement took the Hint, and turns to me, Sir here is no Bread.

After some Time found a Substance adhering to the Crow-bar, which he shook off, tried with the Hammer, and found it Malleable, says, this is certainly Iron ; after five Hours Labour, long look't for came at Last, he drew out a large Loop ; it bore Shingling and Hammering well, and when completed, the Bar weighed Fifty-two Pounds and an Half, and proved

proved excellent good Iron; Part of it was tried by the most Skilful of our black-Smiths, who pronounced it to be equal to the best of refined or *Swedes* Iron.

Some may say, that such trivial Stories, and a long Detail of minute Particulars concerning a little Bag of Sand and a Bar of Iron, is really below the Dignity of Writing. I do not know what such Persons intend, by Dignity of Writing, unless they can Mean, that when a Person is to write a Letter or a Book, he must ascend into the Clouds, think himself going about something quite different from the common Actions of Life: That he must divest him himself of that Sociability, that easy Freedom, that Familiarity which is so much the Support and Pleasure of Conversation; must now put on a distant and forbidding Air, assume a solemn Mein, a formal Stiffness, as if clad in Buckram; and being thus equipped is in Appearance like a Hog in Armour, very different from the inimitable Sir *William Temple*, who relates the common Incidents of Life, in such an easy agreeable Manner, as to engage the Attention, captivate the Mind, and excite the Admiration of every Reader.

The Matter related is not so inconsiderable as some may think, but a Matter of importance; for as to me, it was to know whether these numerous Sand Banks, which as far as we know, may contain Ore for many Thousands of Tons of Iron, should remain useless to Man-

kind, to future Times, as they have in all Ages past. If this Trial had failed, when neither Skill, Care, Pains nor a sufficient Length of Time was wanting, and more especially as the Project did not wear the most promising Face or Prospect of Success ; I think I should not have been so hardy as to have made another Attempt.

It was a discouraging Circumstance that one third Part of the Sand was common Grit Sand, which is hard to Flux, and when it is melted runs into a kind of Glass ; this dry hungry vitrous Matter being more likely to retard than promote the Flux of the Metal, whereas the true Cinder or Slag greatly promotes the Design of reducing the Ore into Iron, and is as useful as the other is prejudicial ; although this Grit Sand doth not prevent the Operation, yet I suppose it to be one Cause why it is so slow in melting. When I gathered that Sand of which the Trial was made, I did suppose that no more could be got till the next Appearance of the Sands.

On the second Week in *January*, I desired my Son to ride to the Beach and see if he could scrape up a little more Sand ; some he found driven on to the Upland, and some in Holes and Corners ;---- mixed it with Bog Ore, and made two Bars of Iron ; as Bog Ore is poor ; and this Sand Ore so good, thought it would make a tolerable Sort of Iron, if it should so happen that the black Sand ~~could~~ be obtained  
but

but in small Quantities ; such a Mixture would be a good Saving.

The third Week the Anvil gives Way, a large Breach is made ; the greater Part of the Week is Spent in cutting it down to make a new Face. This is the third Time the Anvil has failed in this Manner ; and a new Hammer was broken to pieces and wholly spoiled not many Months past : I tell my Son that I think he must send to *England* for a new Supply, where I am informed those which are good may be had ; so much Delay, Expence, and Disappointment, being the Consequence of trusting to those made of such bad Metal ; what he hath in Use being an old second Hand Hammer.

About this Time, and for some Time past ; having been at Work on a Parcel of Pig Iron, which is of such a sharp sulphureous Nature, as frequently to burn and destroy the Tew Irons, which is the Occasion of much Delay and Expence, as well as Loss of Time ; at all Times, and with the best Pig Iron, there is Difficulty and Loss on this Score, though not equal to what it is when they Work those of a sharp Kind. A Tew Iron is a Case of Iron so framed, and of such a Constructure, as to secure the Bellows Pipes from being hurt by the Fire, and to convey and direct the Blast of Wind into the Fire ; I have thought of various Expedients to remedy that Evil, have some Times thought of making them of the Asbestos or Cotton Stone,

or

or of that Composition of which Crucibles are made, but then the Clearing Rod, and the Crow-Bar so often Entering, and the necessary Motion that must be made of the Loop, while in the Fire, and the Drawing it out, will inevitably break such brittle Substance.

There is a Sort of Wood, in or near a Place called the Nine Partners, which is Incumbustible; it will endure strong Heat, will be red Hot, but not consume neither by Length or Strength of Heat; Fire makes no more Impression upon it than on the Asbestos; makes no sensible Diminution of the Substance, or Alteration in Colour or Texture. I once had a small Piece of this Wood; several have seen it in the Possession of others: This Wood is not of a sparry or a strong Substance, but hath all the Properties of Wood, except that strange differencing Quality, that it is Uncombustible.

Some say that there are living Trees of this Kind; others say, that there was only one Log of it, which was discovered by an Endeavour to burn it out of the Way, it was found Impenetrable by Fire; some think that this in Fact is the Case, and that it is All, or the greater Part chiped off, and carried away to shew as a Rarity; that it acquired this singular Property by some Effluvia from the Earth; which is in Truth accounting for one Phænomenon, by another as strange and unaccountable as the first; but let this be as it will, I have employed a young Student of the College, who travels  
into

into that Part of the Country, to get the Best Information upon the Spot that he can, and to procure me a small Piece, if none that are large can be had, that I may send it to the Society in *London*. I imagine that if Pieces of this Wood, whether green or dry, could be procured large enough to make Cases, to serve in the Place of Tew Irons, they would last till they were worn away by Friction ; which would take a long Time, and would endure like Asbestos, called with us Cotton-Stone. The making and mending of Tew Irons is a great Expence of Time and Labour.

The third Week of *January*, I told my Son that it was not unlikely but that our Theory, concerning the appearing and disappearing of the black Sand might be wrong, and instead of being carried off to Sea, they might be buried under common Sand, driven up by Storms and high Tides : At about sixteen Inches depth he found great Plenty ; there were sundry smaller Stratas and one Large, about four Inches thick, clean, heavy, and very black ; soon carried off three Tons to the Works. Finding the black Sand buried under common Sand, quite unraveled the whole Mystery of the Periodical disappearing of the Iron Sand ; but then as to these Sands making their Appearance in the Summer ; a Person of greater Sagacity might have found out the Latter by the Former, but I was not so happy ; I still remained unresolved, and not able to account for it : One of the Cart-  
Loads

Loads of Sand in its Passage to the Iron Works, being stayed for a Time in the Street, there falling a Shower of Rain in the Night, looking on it in the Morning, I observed that the Rain had driven away the common Sand, which is mixed with the Iron Sand, as being surprisingly lighter than the Ore Sand, and had left the Iron Sand like Cream on the Top; I rode down to the Beach, and found the Rain had done the same there, where the Stratum of common Sand was thin: This Observation upon Matter of Fact, resolved two Things, which were Matter of Doubt and Difficulty: First, I learned that it was by Rain that the lighter common Sand was removed, which being repeated, and no Storms to bring up a new Accession of common Sand, the Sand Ore makes its Appearance in its proper Season. The other Difficulty was this, that I had observed that the richest and heaviest Part of the Iron Sand, was on the Surface of the Beach; which seemed to be contrary to the Law of Gravitation; but these Matters of Fact, shew, that it is so far from being contrary to the Law of Gravitation, that it is fully Agreeable to it. I should not have been so long and particular on this Article, but on Supposition that it may be servicable to Those who may be in Search after these Sands.

When we meet with Difficulties relating to natural History, for which we are not able to Account, when by Experience and Observation, the

the Whole of that which seemed to be so mysterious, comes to be fully explored, we wonder at our former Blindness ; and to others who had never been perplexed with them, and now see them in full Light, they appears so plain, natural and easy, they think that the Discovery is not in any Degree Meritorious.

The Manufacturing of Sand into Iron having made a great deal of Noise far and wide, I was informed of many more Places where there is an Appearance of these Sands, than ever I had any Knowledge of before : I heard that there was of it at Seabrook, a large Bank of it at New-London, at Block-Island, at Long-Island, on the North and South Side ; at Guilford, at Branford, and at New-Haven, besides what we have in this Town, from whence my God gathers what he makes use of. It is many Years since I have seen the Book, if I remember right, Gordon in his Geographical Grammar, writes of a Beach of black Sand at New-Haven, as one of the Rarities of New-England.

About this Time, sent my Sons East and West to search for Iron Sands, but found them covered up, and not knowing exactly the Spot, where these Sands were wont to make their Appearance, found none that was very good . I think that it would be acting a prudent Part, for Persons where the black Sand makes its Appearance, to drive down a Stake in that Spot, that so it may be known where  
to

to dig, and to gather up what is on the Surface in these Seasons, and put it into Bells prepared for that Purpose.

About this Time go to *New-Haven*, and bring with me two artificial Magnets, with a Design to know what Proportion of Iron, is contained in each of these several Sorts of Iron Sand; these Magnets are made at that Town, by a Workman who received his Instructions from that learned and ingenious Gentleman *Joseph Harrison, Esq;* the red Sort being the poorest of all the Iron Sand, the Magnet could separate only one eighth Part and a half, it seemed to be but dry hungry Particles of Iron, being extracted from the Sand, by the strong Force of the Magnets; that of a deeper red one Quarter, others an Half, some two Thirds, and some more, that which yields two Thirds Ore, is that of which my Son makes his Iron. Every Week's Experience affords a new Accession of Knowledge, and opens a new Scene of Wonders, and furnishes out a new Set of Ideas. Having now found a Plenty of Sand Ore, and carted up something of a Stock for the Present, after a Time go on to make Sand Iron successfully, making Loops of which each affords a Barr of Iron, of two or three and Fifty Pounds. It still continues to Work but slowly, which is strange, considering the fine Particles of which the Sand doth consist; takes more Time than either Bog Mine, or Mountain Ore; hope however, that in Time

convenience, may be found for this Evil or Inconvenience, the Sand contained in it, I suppose to be an Obstruction. The Iron made of Sand Ore, is not only fit to answer all the ordinary Purposes for which Iron is used, but it seems to be well fitted for, and to have all the Qualities requisite for making Steel for Edge Tools.

13, In the first Place, this Iron is soft; the popular or vulgar Notion is, that the hardest Iron is best for Steel; this I suppose to be a Mistake, founded on a Conjecture, that Steel is no other than Iron made hard; if this were the Case, a great Degree of Hardness in Iron would forward the Operation; as this Iron is soft, so the heat and virtues of the Ingredients made use of in making the Change, will the more effectually Penetrate, in order to make a full Conversion of the Iron to Steel.

14, This Iron is pliant, or as we vulgarly say, tough. In Iron Bars there is a Grain, which runs the whole Length of the Bar, which is sometimes visible to the naked Eye; in breaking a very tough Bar of Iron, the Fibres appearing in some Measure resembling the Grain of Wood; the more distinct and connected these Fibres are, so much the more pliant and tough. If this be true in Fact, we see what is the Cause of the Pliancy or Toughness in Iron; I suppose it to be a necessary Property in Iron, to render it fit for making the best Steel for Edge-tools.

Another Property of this Iron is, that the Grain is fine; The Particles or Grains of Gold are fine, and consequently connected, which is one Reason of its Ductility.

If I have any right Notion of the Manner in which Iron is cleansed or converted to Steel it is this; that when the Iron lies confined in the Stone Chest or Box, the Heat and the Virtues of the Ingredients communicate, cut and divide these Fibres into Angles, resembling Diamond Points; if the Grains which go to constitute the Fibres or Filaments, are fine, so much the finer will the Angles or Diamond Points be; and by how much the more Pliant and Tough these Fibres or Filaments are, so much the stronger they will be, and the Angles into which they are divided; and consequently so much the better to cut, and bear force as in Axes and Stone Chisels, where Steel is put to the hardest Trial.

Iron when it is enclosed in the Chest is greatly expanded; as appears by the Blisters that rise on the Bar; this Expansion is the Cause of such a strong Tension upon the Grain or Filaments, as to snap them off Short; an hard Substance thus broken short, necessarily forms into Angles, or Diamond Points; if the Change be not brought about in this Manner, I must confess I am not able to account for it at all.

It is said that the Edge of an Ax, Knife or Razor, viewed through a Microscope, appears like a fine Saw; it is probable that this is a true

true Representation, as the Edge is composed of a Row of these Angles or diamond Points ; so that to speak strictly and philosophically, that which is cut is sawed asunder. As all Theory not founded upon Matter of Fact, and that is not the Result of Experience, is vague and uncertain ; therefore it is with great Diffidence that I have offered any Thing in Way of Theory, which is only conjectural, and shall always take it as a Favour to be corrected and set right ; for I suppose that the greatest Obstruction to the Increase of Knowledge is Pride and self-Sufficiency. I have learned many useful Things from the lowest of the People, not only in Rank, but in Understanding too. Most Men by their Observation and Experience arrive at the Knowledge of some thing not known to others, *let each esteem Others better than themselves.*

One of the Ways in which Steel is prepared for medicinal Uses, is by applying a Bar of red hot Steel to a Roll of Brimstone, holding it over a Vessel of Water, the Steel will melt and fall down in Drops into the Water, the Water being poured off, and the Steel dried, in a metal Mortar it may be reduced to powder like prepared Coffee : This being Matter of Fact, I thought that there was Reason to conclude, that when Steel or Iron was too hard and touchy (as the Smith's say) would not bear the Hammer, it would break and fly to Pieces, especially when welding hot : With such

Stuff the black Smith spends his Time, his Coal, his Patience, and his Reputation with his Customers ; he has paid his Money for it, therefore cannot afford to lose it, goes on striving to work it, but strives in vain ; I suppose that these bad Qualities in Steel and Iron, is owing to a too great Quantity or Proportion of Sulphur in its Composition.

Therefore in Order to resolve this Question, and to determine whether the Brittleness of Steel or Iron, be owing to an abounding of sulphureous Particles, and for a Remedy at the same Time ; from a Number of Bars of bad Steel, I chose a Bar the most friable, touchy, and the worst I could find ; but lest I might be mistaken, and that it might be better than I had judged I ordered the Smith to try it, and found it as bad as it was supposed to be, and full as bad or worse than above described.

Having slacked Lime in Readiness, I directed the Smith to use this Lime as they use Clay, to save the Steel or Iron from burning, with this Alteration only, that he should cast into the Fire more in Quantity, than what they use of Clay ; and to give it a welding Heat ; when it was taken out and hammered, there fell off a thick Scale from the Steel, which when broken was white within, occasioned by the Lime that was mixed with the Cinders ; the Effect was, that after this Operation, the Steel was malleable, and could be wrought very well in the common Way with Clay.

The

The Steel being thus exposed on all Sides, with  
 certain Causes, the Superfluous Particles were dis-  
 tressed, or else consumed, something analogous  
 to ancaling.

I must confess that I made only this single  
 Trial; it hath not been usual with me to pub-  
 lish or recommend any Thing upon one single  
 Experiment: Some Smith's to whom I com-  
 municated the Method say, that they have tried  
 it with success. As there hath been some Pig  
 Iron made of such sulphureous Metal, as to be  
 matter of Terror and Vexation to Refiners; it  
 may be worth while to try this Method upon  
 the Iron made of such bad Pig Iron; the Way  
 is cheap, easy, and as I suppose harmless; if  
 it prove a Cure of the ill Quality of such  
 Iron, it may prove of considerable Advantage  
 to the Publick. Intimations of this Kind,  
 crude and imperfect, and not supported with  
 repeated Experiments may at least give an  
 Handle to further Improvements. The Iron  
 made of Sand Ore seems to have no more  
 Sulphur in its Composition than is in due Pro-  
 portion.

If I am mistaken as to the Cause of the Brit-  
 tleness of Steel and Iron, it is the Practice of  
 melting Steel with Brimstone has led me astray;  
 for when we see good malleable Steel in a Mo-  
 ment rendered as brittle as China Ware, only  
 by mixing with the Steel, particles of Brimstone,  
 can we think otherwise? To this it may be  
 objected, that Iron when melted or fused by

Heat

stone, will become brittle as all Cast Iron is known to be; but that Cast Iron cannot be pulverised as Steel or Iron may be, when mixed with Brimstone; how wrongsoever I am in Theory, yet if in Fact it should be found by Experience, that Lime applied as above, should be a cure for bad Sand and Iron, we shall have the Benefit of the Effect as in the Lead Stone, though we mistake the Cause.

Iron being so necessary for the carrying on of Husbandry, Arts and Navigation, as hath been intimated already, there being as yet no more Iron Ore found, than only two Beds of Mountain Ore, one at New-Milford, and another at Salisbury, and a small Master of Bang-Mine; and the greater Part of that at Salisbury, being transported out of the Government, and never returning again but by Purchase, there remains no more wholly belonging to this Colony, save only that of New-Milford, that and a small Part of Salisbury Mine, being all that we can call our own; and this being so utterly insufficient to supply so great a Demand, unless a Furnace be erected to render the New-Milford Ore more extensively Useful, or these Iron Sands, or both, afford a much larger Supply than at present; other Colonies must still, as they have done, draw from us large Sums Yearly, which we can but ill spare; in the Purchase of Pig Iron, we give One-Half by Manufacturing, for although there is but little Gain accruing to the Manufacturer, yet it

in raising of. Half to the Colony; the Importation of Bar-Iron lies upon us as a heavier Load, being in the Whole obtained by Purchase.

There are promising Appearances of Sand Ore in many Places in this Colony, but what those Beaches may afford, no Man can tell, whether much or little, it being no Season to examine that Matter; if they should all be as well lined within, as that Short Beach from which my Son draws his Supply, they may prove greatly to our advantage: There may be enough, together with what Mountain and Bog Ore we have, to supply the whole Government and for Exportation too; of which we have great Need, having no one Product of which we can make an immediate Remittance in Payment for the Abundance of English Goods, which our increasing Wants call for.

I presume that no Person will pretend to set up Iron Works, on Dependence of Working these Ore-Sands, till they have first gathered up what can be had on the Surface of the Beach, from whence they expect to be supplied; and then search to see what can be had by Digging; and gather to the amount of Three or Four Hundred Tons, with a good Prospect of getting farther supplies: for what is so uncertain, had need be made as sure as the Nature of the Thing will allow, before they put themselves to the Charge of erecting Works to carry on the Manufactory. Many and great are the Advantages which may arise from these Ore Sands,

Sands, in Case they should be found in a great Quantity, and of a good Quality, such as these already Found.

1<sup>st</sup>, From the Situation, being adjacent to the Sea, convenient for Transportation, to be conveyed into Rivers on which Iron Works in Time may be erected; the Convenience of Water bearing, and the cheap Conveyance compared with the heavy Charge of Land Carriage, is obvious to every one, too plain to need any farther Enlargement on this Head.

2<sup>d</sup>, As it generally, I suppose, requires five Tons or more of Bog Ore, to make a Ton of Iron, and from three to four Tons of Mountain Ore to make one Ton of Iron, and from Twenty-eight Hundred to one Ton and Half of Pig Iron, to make one Ton of Iron; Of this Sand Ore, it requires no more than two Tons, to make one Ton of Iron, which is also of small Cost; so then in Case of Land Carriage, this Sand Ore will bear more than double the length of Mountain Ore or Bog Ore; that is to say, this will as well bear the Charges of ten Miles Land Carriage, as the other Sorts of Ore five Miles.

3<sup>d</sup>, If there should ever be found a sufficient Quantity of this Sand Ore, to supply a Furnace, it is all ready pulverised and washed clean to your Hand; washing and pulverising the Ore; is I suppose an Article of considerable Expence; but as this Sand Ore is so pure, so clean, and producing as good Iron by Chaffing, as that

that made from Elms by using, if by any Means the sinking a Loop of this in the Chaffery, could be brought within the Compass of a House; it would never turn to any possible Account to erect a Furnace; nay, if the sinking a Loop could be brought within the Compass of three Houses.

4th. The Gathering, Digging, Raising and Filling of Carts or Boats, with this Sand Ore is cheap, compared with the Charge of digging and raising Mountain or Bog Ore.

5th. As our Manufactures are small, and our Manufacturers few in Number, compared with the great Extent of our Agriculture, (which is still increasing) and the great Numbers employed in that great and useful Branch of Business is such, that in plentiful Years the Product so far exceeds the Consumption, as to overstock all the Markets far and near; when in Consequence of this, the rich valuable Product of the Earth, lies upon the Hands of the Farmer, it is discouraging, and of bad Tendency, tends to enervate and abate the Vigour and Zeal of the Farmer, renders him Indolent, takes off the Edge of Industry. But if great Numbers were employed in and about Manufactures in Iron, this would bring Colliers, Carters, Bloomers, Carpenters, into a necessary Dependence on the Farmer, and by a home Consumption make the most sure and certain Market.

By 6, I have contriv'd an Engine, by which  
 not only the third Part Spunk, may be Sepa-  
 rated from the richest and best Sand Ore, but  
 also from the poor Sand, such as con-  
 tains but one Half, one Quarter, or one  
 eighth Part Iron Ore, and will (as I suppose)  
 be performed with Ease, and with such Speed  
 as to turn to good Account, which will  
 be a good Saving, where richer Sands are  
 not to be found.

When I wrote the foregoing Essay, I was not  
 certain whether three or four Tons of the  
Mountain Ore would produce a Ton of  
Iron, I am now certain that at New-Mil-  
ford, they always reckon four Tons, as a  
Ton of Iron.

**F I N I S.**





































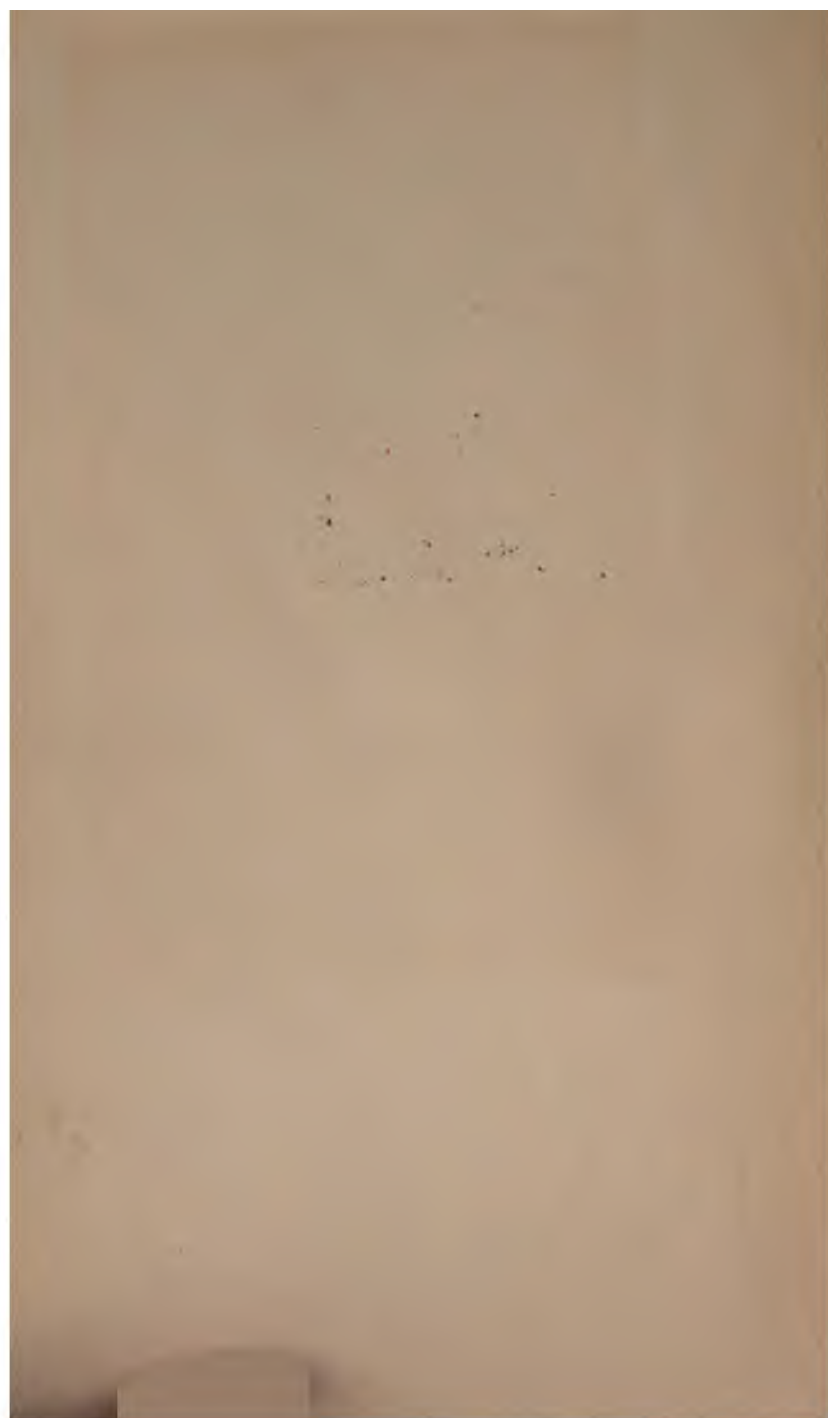














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the 1990s, the number of people in the world who are under 15 years of age is expected to increase from 1.1 billion to 1.5 billion.

As the world's population grows, the need for more food and other resources grows. The world's population is expected to reach 6 billion by the year 2000, and 8 billion by the year 2025.

The world's population is growing so fast that it is expected to reach 10 billion by the year 2050.

The world's population is growing so fast that it is expected to reach 12 billion by the year 2100.

The world's population is growing so fast that it is expected to reach 14 billion by the year 2150.

The world's population is growing so fast that it is expected to reach 16 billion by the year 2200.

The world's population is growing so fast that it is expected to reach 18 billion by the year 2250.

The world's population is growing so fast that it is expected to reach 20 billion by the year 2300.

The world's population is growing so fast that it is expected to reach 22 billion by the year 2350.

The world's population is growing so fast that it is expected to reach 24 billion by the year 2400.

The world's population is growing so fast that it is expected to reach 26 billion by the year 2450.

The world's population is growing so fast that it is expected to reach 28 billion by the year 2500.

The world's population is growing so fast that it is expected to reach 30 billion by the year 2550.

The world's population is growing so fast that it is expected to reach 32 billion by the year 2600.

The world's population is growing so fast that it is expected to reach 34 billion by the year 2650.

The world's population is growing so fast that it is expected to reach 36 billion by the year 2700.

The world's population is growing so fast that it is expected to reach 38 billion by the year 2750.

The world's population is growing so fast that it is expected to reach 40 billion by the year 2800.

The world's population is growing so fast that it is expected to reach 42 billion by the year 2850.

The world's population is growing so fast that it is expected to reach 44 billion by the year 2900.

The world's population is growing so fast that it is expected to reach 46 billion by the year 2950.

The world's population is growing so fast that it is expected to reach 48 billion by the year 3000.

The world's population is growing so fast that it is expected to reach 50 billion by the year 3050.

The world's population is growing so fast that it is expected to reach 52 billion by the year 3050.